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Meniscal ramp lesions should be considered in anterior cruciate ligament-injured knees, especially with larger instability or longer delay before surgery

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Abstract

Purpose To determine the incidence of meniscal ramp lesions in an anterior cruciate ligament (ACL) injured knees and to clarify whether ramp lesions are related to chronic ACL deficiency and increased knee instability.

Methods Consecutive ACL injured patients were evaluated arthroscopically for a ramp lesion via a trans-notch view and evidence of menisco-capsular injury was recorded. Other concomitant injuries to the knee were also noted. Incidence of meniscal ramp lesions, delay before surgery, and anterior–posterior stability was analyzed. All patients underwent bilateral KT-2000 evaluation.

Results One hundred and three consecutive ACL injured patients with a mean age of 24 years were included in this study. In total, a ramp lesion was found in 10 knees (9.7%) via a trans-notch view. None of these lesions could be identified by the standard view from the anterolateral portal. Other medial meniscal lesions were found in 26 knees (25.2%) by standard arthroscopic viewing. The ramp lesion group had significantly longer delay before surgery with a median of 191 days ($p < 0.01$) as well as a larger side-to-side difference of KT-2000 measurement (7.3 ± 1.8 mm; $p < 0.01$), compared with the intact medial meniscus group (53 days and 5.5 ± 1.5 mm, respectively).

Conclusion Ramp lesions that were identified using a trans-notch view were not visualized with standard arthroscopic views. Increased anterior tibial translation and longer delay before surgery were seen in knees with ramp lesions. Careful inspection of the posteromedial menisco-capsular region is required as hidden menisco-capsular lesions may occur which may result in residual knee instability.

Level of evidence Level II.

Keywords Anterior cruciate ligament injury · Reconstruction · Ramp lesion · Meniscus injury · Trans-notch view · Menisco-capsular junction

Abbreviations

ACL	Anterior cruciate ligament
MCL	Medial collateral ligament
PHMM	Posterior horn of the medial meniscus
MRI	Magnetic resonance imaging
PCL	Posterior cruciate ligament

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Introduction

The meniscus plays an important role in shock absorption and biomechanical knee stability [38]. The medial meniscus has a firm attachment to tibial plateau with its roots and meniscotibial ligaments which assists in the control of tibiofemoral laxity at the medial aspect of the knee joint [26, 29, 30, 39]. In anterior cruciate ligament (ACL) deficient knees, the medial meniscus functions as a secondary stabilizer of the knee, restricting anterior tibial translation in response to anterior tibial load [1, 2]. Injuries in the posterior horn of the medial meniscus (PHMM) cause disfunction of this restrictive mechanism and can lead to increased anterior tibial translation in ACL-deficient knees. In the ACL-deficient knee, medial meniscus tears may lead to increased anterior

and rotatory instability. These tears often are observed at the posterior and peripheral regions near the posterior joint capsule, especially in chronic cases [12, 20].

Ramp lesions are a tear of the menisco-capsular junction of the PHMM and are commonly associated with ACL deficiency [27]. Because of its posterior location, ramp lesions are commonly overlooked during arthroscopy, if evaluated by standard anterior portal views only. Therefore, these are sometimes referred to as "hidden lesions" by orthopaedic surgeons [32]. Even with magnetic resonance imaging (MRI) examination, ramp lesions are difficult to visualize when compared with medial meniscal body tears [5, 14]. However, it is important to detect meniscal ramp lesions in ACL reconstruction surgery as it has been associated with increased anterior tibial translation and non-physiologic tibial rotation [27, 31]. Accurate detection of meniscal ramp lesions based on correct knowledge of their characteristics would help surgeons to decrease missed injuries and repair these ruptured menisco-capsular junctions with the goal of avoiding residual knee instability and increased stress on the ACL graft [6, 28, 34].

The trans-notch view makes it possible to access the posterior medial compartment relatively easily from the standard anterior portals without creating any additional portals. It allows visualization of the posterior horn, root and posterior menisco-capsular junction (Fig. 1) [33]. Since December 2017, the posteromedial compartment, including the injury of the posterior menisco-capsular junction, has been evaluated prospectively via trans-notch view with every ACL reconstruction surgery in our department.

The purpose of this study was to determine the incidence of meniscal ramp lesions in ACL-injured knees using the trans-notch view and to clarify the characteristics of knees with ramp lesions associated with ACL-deficiency. It was hypothesized that (1) ramp lesions would be commonly observed in ACL injured knees, especially in chronically deficient cases; and (2) they would be associated with increased anterior tibial translation.

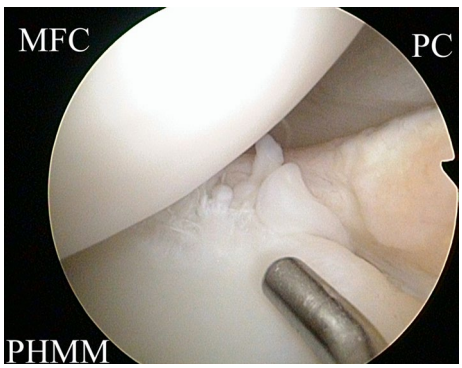

Fig. 1 A trans-notch arthroscopic view (modified Gillquist view) is shown. Disruption of the posterior menisco-capsular junction of the medial meniscus is visualized in this case. *MFC* medial femoral codyle, *PHMM* posterior horn of the medial meniscus, *PC* posterior capsule

Materials and methods

This study was approved by our institutional review board in Kyushu Rosai Hospital (IRB No. 19-17) and all subjects provided informed consent before they were enrolled. One hundred and eleven consecutive ACL injured patients were prospectively recruited from December 2017 to March 2020. Six revision ACL reconstruction cases and two cases with a past history of meniscectomy were excluded. Subsequently, 103 ACL injured knees were included in this study. Fifty-nine were male and 44 were female. The mean age was 24 (range 12–49) years old. During arthroscopic evaluation and before ACL reconstruction, the operative leg was positioned in a leg holder with the knee maintained at 90° of flexion, and the posteromedial compartment was carefully examined by a trans-notch view, as well as by standard views from the anterolateral portal in each case. The arthroscope was passed through the anterolateral portal and inserted between the posterior cruciate ligament (PCL) and the medial wall of the intercondylar notch into the posteromedial compartment and then rotated 90°. When insertion of the arthroscope was not easy, valgus stress was applied to the knee and a blunt obturator was inserted first to feel for its passage. A tear of the menisco-capsular junction of the PHMM was surveyed, separately from other types of medial meniscus lesions such as root tears, horizontal tears, radial tears and vertical tears in white–white or white-red zone. Tear length and depth were estimated using a probe with a scale.

The incidence of meniscal ramp lesions in ACL injured knees was then determined. The incidence of other types of meniscus injuries as identified from standard anterior viewing arthroscopy was evaluated separately. The delay from an initial ACL injury to surgery was also surveyed. Anterior–posterior stability was evaluated pre-operatively with a KT-2000 arthrometer (MED metric Corp, San Diego, California) at 133 N anterior force. The subjective knee function was assessed with the Lysholm scoring scales and KT-2000 measurement was performed at the final follow-up in the ramp lesion group. Results from the KT test and arthroscopy were blinded during data collection and evaluation.

Statistical analysis

The unpaired *t* test was used to analyze differences of KT-2000 arthrometer measurements between two groups of patients: one with ramp lesions and the other without ramp lesions or any other medial meniscus injuries. The Mann–Whitney *U* test was used to compare differences in

surgical delay from ACL injury to surgery between the two groups. Power analysis was performed on Chi square (significant level = 0.05, power = 0.80, proportion 1 = 10% and proportion 2 = 1%) to indicate sample sizes of 100 could address the questions. The JMP® 9 software program (SAS Institute Inc., Cary, NC) was used for statistical analysis.

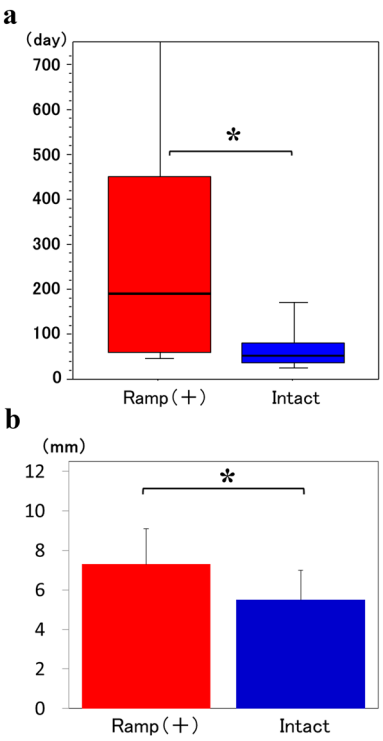

Fig. 2 **a** Time from an initial ACL injury to surgery in ramp lesion group and intact medial meniscus group are shown in box and whisker plots. The median values of each group are displayed inside the box as the heavy line. The box is drawn from the first and third quartiles. Whiskers represent the 10th percentile and the 90th percentile. *$p < 0.01$. **b** Mean side-to-side difference of KT-2000 in ramp lesion group and intact medial meniscus group are shown

Results

Of the 103 cases evaluated, a ramp lesion was found in 10 knees (9.7%). In these 10 knees, menisco-capsular injuries were unable to be visualized with the standard views from anterolateral portal but were identified by the trans-notch view. Other types of medial meniscus lesions were seen in 26 knees (25.2%) and were found using the standard view from anterolateral portal (16 vertical tears, 6 bucket hundle tears, 3 flap tears and 1 radial tear). The delay from injury to surgery was a median of 191 days in the ramp lesion group which was significantly longer than in intact medial meniscus group (median = 53 days, $p < 0.01$) (Fig. 2a). Mean side-to-side difference of KT-2000 was 7.3 ± 1.8 mm in ramp lesion group and 5.5 ± 1.5 mm in intact medial meniscus group (Fig. 2b), showing larger anterior tibial translation in ramp lesion group ($p < 0.01$). In other types of medial meniscus lesion cases, the time from injury to surgery was a median of 72 days and mean side-to-side difference of KT-2000 was 6.0 ± 2.0 mm.

Further characteristics of the 10 cases with ramp lesions and their treatment are presented in Table 1. Overall, long unstable ramp tears were fixed using an all-inside repair device, while short stable tears were left in situ. After an average follow-up of 1.1 years, a mean side-to-side difference of KT-2000 was 0.8 ± 0.7 mm. No catching, locking or giving way sensation was observed in postoperative knees and the last Lysholm score was an average of 97.5 ± 3.5. A case example of a 27 years old male patient with an ACL deficient knee and a ramp lesion is shown in Fig. 3.

Table 1 Characteristics of 10 cases with ramp lesions

Age			Mean 24 y.o. (range 14–49)
Sex			Male: 5, female: 5
Time from inj.			Median 191 days (range 43–10,954)
SSD of KT-2000			7.3 ± 1.8 mm
Tear length	Tear depth	Stability of meniscus body	Treatment
< 1 cm	Superficial ($n = 3$)	Stable	Abrasion for 1 case
	Full thickness ($n = 1$)		No treatment for 3 cases
1.5 to 2.0 cm	Partial thickness ($n = 3$)	Unstable tibial side	Repair with 1 suture
	Full thickness ($n = 2$)	Unstable	Repair with 1 or 2 sutures
> 2 cm	Full thickness ($n = 1$)	Unstable	Repair with 3 sutures

Age age at the time of surgery, *Time from inj.* Time from initial injury to ACL reconstruction, *SSD of KT-2000* side-to-side difference of KT-2000 measurement

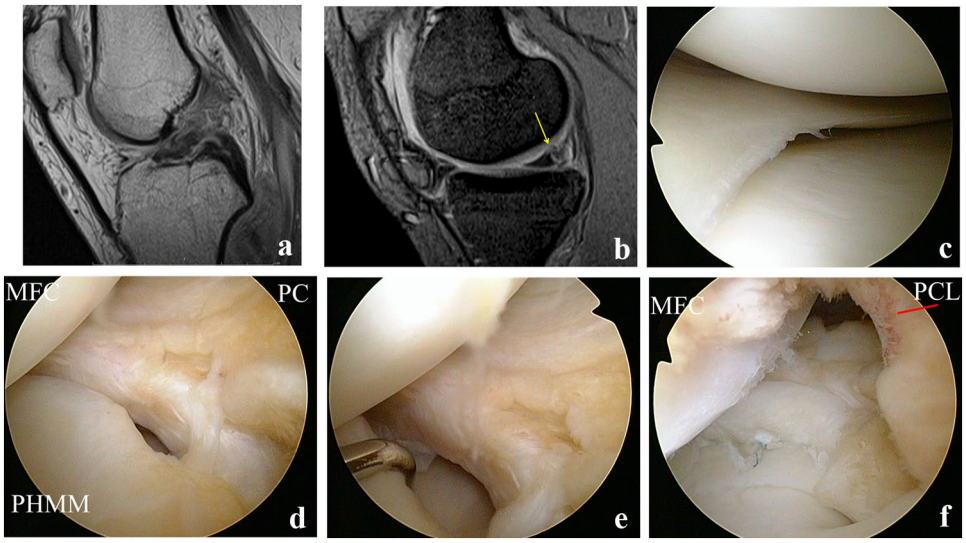

Fig. 3 A case example of a 27-year-old male patient is shown with a left ACL injury while playing rugby. He previously underwent conservative treatment with functional bracing for 3 months with rehabilitation. He had returned to playing rugby without symptoms but re-injured his left ACL 11 months after his initial injury. **a** Proton density sagittal MR image shows torn ACL. **b** T2-weighted sagittal MR image shows high signal intensity change near between the posterior medial meniscus and capsular margin (arrow). **c** Arthroscopic view from standard antero-lateral portal. No obvious injury to the medial meniscus is seen. **d** Trans-notch view shows menisco-capsular injury (ramp lesion). The arthroscope was passed between the PCL and the medial wall of the intercondylar notch. **e** When examined with a probe, the substance of the posterior medial meniscus showed abnormal increased mobility. **f** The ramp lesion was repaired using a FasT-Fix® (Smith & Nephew Endoscopy) all inside the device. *MFC* medial femoral codyle, *PHMM* posterior horn of the medial meniscus, *PC* posterior capsule, *PCL* posterior cruciate ligament

Discussion

The most important finding of the present study was that meniscal ramp lesions were found in 9.7% of ACL injured knees upon evaluation with the trans-notch view and were not identified with a careful inspection from the standard anterolateral portal views. Significantly larger anterior–posterior instability was demonstrated in the ACL injured knees with ramp lesions compared to ACL injured knees without meniscal lesions. Ramp lesions were found more frequently in chronic ACL deficient knees with a longer delay from the initial ACL injury to surgical intervention.

Incidence of ramp lesions are reported to be 9% to 24% based on arthroscopic findings in previous studies [5, 8, 9, 19, 21, 31, 33, 42]. One of the reasons for variation in its reported incidence may be relatively low sensitivity of MRI as well as these being missed with standard anterior portal views only. Although some ramp lesions may be detected preoperatively using high-resolution MRI [3, 13], it is not as accurate as a diagnosis for common meniscal body tears [5, 8, 11, 14]. Our group inspected the posteromedial compartment and PHMM directly via trans-notch view as well as the standard views and found an additional 9.7% menisco-capsular injury. This incidence was similar to those (9.3% and 9.6%) reported in previous studies which utilized a trans-notch view [5, 9]. The trans-notch view procedure was technically equivalent to modification of the Gillquist view, but we went through the anterolateral portal and did not penetrate the patellar tendon [10, 18].

The incidence of ramp lesions was higher (16.6–24%) in other studies which created an additional posteromedial portal [19, 21, 31, 33]. The advantage of the trans-notch or Gillquist view is the avoidance of the creation of another portal. The authors believe that if the ramp lesion is substantial, it likely will be able to be perceived with the trans-notch view making the posteromedial portal typically unnecessary. An even higher incidence of ramp lesions (> 30%) was reported in other studies based on MRI findings [4, 17], but not all of those cases with signal changes were confirmed with arthroscopy. Although the incidence of ramp lesions in our study was not as high as the rates reported with an inspection from the posteromedial portal, adding the trans-notch view can help to detect almost 10% of hidden meniscal lesions near the PHMM in those with concomitant ACL injuries that otherwise would be overlooked.

The medial meniscus plays an important role in anterior–posterior stabilization of the knee, especially in the absence of normal ACL function [1, 2, 23]. Loss of this secondary stabilizer in ACL deficient knees can lead to an increase of instability and early onset of osteoarthritis. Even in ACL reconstructed knees, dysfunction of the medial meniscus may increase the ACL graft forces in the early

phase of graft healing. This may result in residual knee instability. Recent studies on ramp lesions with concomitant ACL injury reported increased anterior tibial translation or rotatory laxity in vivo [21, 33] and in vitro [34]. Although the medial meniscus is firmly attached to the proximal tibia, disruption of posterior menisco-tibial ligament has been suggested to be associated with increased instability of the posterior horn [27, 36]. Therefore, arthroscopic repair of ramp lesions at the time of ACL reconstruction has been advocated by some researchers [1, 15, 34, 37]. Increased anterior tibial translation was shown in the ramp lesion group in the current study which may result in larger instability in ACL deficient knees. In the current study, meniscal repair was done before the ACL reconstruction if meniscal lesions were long, full-thickness and unstable. As other researchers also have stated, not all ramp lesions may require repair as they are located near the red–red zone with good vascularity. Therefore, shorter and stable tears likely heal conservatively if the knee is stabilized after ACL reconstruction [16, 25, 41]. The authors of the current study agree with this and, therefore, superficial or short tears were not repaired if they were stable upon probing.

The delay from an ACL injury to surgery was significantly longer in the ramp lesion group than in the intact medial meniscus group. This is consistent with recent studies in larger cohorts [19, 33]. In another previous study, posterior menisco-capsular disruption of the medial meniscus was significantly increased in chronic ACL injuries compared with acute injuries, although they did not refer to these as ramp lesions [40]. It was reported in a cadaveric study using a robotic system that the resultant forces on the medial meniscus in response to a combined anterior and axial compressive tibial load were doubled after ACL transection [23]. Although ramp lesion can occur also in acute ACL injury due to high-energy traumas, the increase in the prevalence of medial meniscus injuries with the time from an initial ACL injury may suggest that the instability associated with ACL deficiency is harmful to the medial meniscus [7, 19, 24, 40]. To avoid creation or complications of these meniscal injuries, it is important to diagnose and treat the ACL tear without significant delay after injury. Especially in chronic cases with longer delays before surgery, an occurrence of ramp lesions should be considered during ACL reconstruction and must be evaluated appropriately using a posteromedial portal or a trans-notch view. It is recommended by recent studies that debridement of soft-tissues should be performed to identify possible hidden lesions covered by synovial tissues, using a probe or shaver through a posteromedial portal [6, 9].

One limitation of this study is that the sample size is relatively small. Secondly, the posterior horn of the medial meniscus was inspected via a trans-notch view only and a posteromedial portal was not created. Inspection through the posteromedial portal may perhaps detect more menisco-capsular junction injuries, but this requires more time and is invasive for a screening procedure [22]. The authors consider the trans-notch view as a more efficient way for screening for ramp lesions while creating a posteromedial portal can be considered when a repair of massive tear ramp lesion is required [15]. Third, rotatory stability was not evaluated quantitatively. The pivot-shift test was examined in every case preoperatively but was not quantified [35].

With regard to the clinical relevance, in cases of ACL injuries with substantial instability, or with a longer delay from injury to surgery, consideration of a ramp lesion must occur preoperatively and the posteromedial corner should be inspected intraoperatively. Careful examination for ramp lesions would decrease missed injuries and likely avoid residual instability.

Conclusion

Ramp lesions that were identified using a trans-notch view were not visualized with standard arthroscopic views. Increased anterior tibial translation and longer delay before surgery were seen in knees with ramp lesions. Careful inspection of the posteromedial menisco-capsular region is required as hidden menisco-capsular lesions frequently occur which result in residual knee instability.

Author contributions YT designed the study, performed surgery, data collection and analysis. He drafted the manuscript. TM also performed surgery, assisted data collection and evaluation. TK assisted designing the study, evaluated the data and co-supervised the clinical aspect of the study. TO assisted data collection, analysis and evaluation. JA advised in a study designed, manuscript preparation, and editing as a native English speaker. FF advised the study design and directed all clinical aspects. He examined the validity of data analysis and supervised the entire research. YI assisted in designing the study and co-supervised the entire research.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Ethical approval This study was approved by our IRB in Kyushu Rosai Hospital (IRB No. 19–17) and all subjects provided informed consent before they were enrolled.

Informed consent Informed consent was obtained from all individual participants included in the study.

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