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Axial alignment of the lower limb in patients with isolated meniscal tear*

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Abstract: Meniscal tears do not always result from trauma. To elucidate other factors responsible for meniscal tears, we evaluated the axial alignment of the lower limb in 385 patients (385 menisci) with isolated meniscal tear who were examined between 1972 and 1994. The patients were aged 50 years or less and had no ulceration or defect of articular cartilage of the knee when examined arthroscopically. Of the 385 menisci, 90 were lateral complete discoid; 110, lateral incomplete discoid; 68, lateral semilunar; and 117, medial semilunar. Patients in each of these four groups were divided into four subgroups according to sex and whether there was an obvious history of trauma. The so-called Mikulicz's mechanical axis of the affected side was utilized to evaluate the alignment.

The axial alignment of the lower limb was normal in the patients with isolated tears of lateral complete discoid meniscus, lateral incomplete discoid, or lateral semilunar. It appeared that the axial alignment of the lower limb did not have a relationship with the occurrence of these tears. Patients with isolated tears of medial semilunar meniscus without obvious trauma, showed varus deformity of the knee. This deformity appeared to be closely related to the presence of medial meniscal tear.

Key words: knee, meniscus, rupture, etiology, alignment

Introduction

The meniscus in the knee joint has a buffer action against the weight-bearing load on the lower limb. Malalignment of the lower limb may therefore cause meniscal tears, but there are few reports concerned with this aspect.

The purpose of this paper was to evaluate the axial alignment of the lower limb in patients with isolated meniscal tear and to analyze the relationship between the meniscal tear and the alignment paying attention to whether the patient had an obvious history of trauma (defined as contusions or sprains) at the onset of symptoms.

Patients and methods

We arthroscopically observed 1024 meniscal tears without ligamentous injuries between 1972 and 1994. Patients who were aged more than 50 years and who had ulceration or defect of articular cartilage were excluded from this study, consequently 385 patients (385 menisci) were analyzed for this study. Of these 385 menisci, 90 were lateral complete discoid (LCD group), 110 were lateral incomplete discoid (LID group), 68 were lateral semilunar (LS group), and 117 were medial semilunar (MS group). The average ages of the patients were 25.9 years (range, 8–50 years) in the LCD group, 23.9 years (range, 11–49 years) in the LID group, 24.9 years (range, 15–50 years) in the LS group, and 31.5 years (range, 12–50 years) in the MS group.

Each group was subdivided into males and females, and these groups were subdivided according to whether the patients had an obvious history of trauma at the time of symptoms onset (Table 1).

As a control (normal group), we examined 51 knees in men (average age, 22.3 years; range, 12–47 years) and 33 knees in women (average age, 21.6 years; range, 12–38 years). They showed no ligamentous injuries, no abnormal radiographic findings, and no meniscal and chondral lesions by arthroscopy. Their diagnoses were disorder of plica synovialis mediopatellaris in 29, monoarthritis in 8, pigmented

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Table 1. Groups of patients with isolated torn meniscus

	LCD		LID		LS		MS	
	M	F	M	F	M	F	M	F
Trauma (−)	27	44	36	41	29	12	72	16
Trauma (+)	9	10	17	16	21	6	22	7
Total	36	54	53	57	50	18	94	23

LCD, Lateral complete discoid; LID, lateral incomplete discoid; LS, lateral semilunar; MS, medial semilunar; M, male; F, female

villonodular synovitis (localized nodular type) in 4, synovial chondromatosis in 4, and unknown (arthroscopically normal) in 39.

A comparison between the involved and the asymptomatic sides in the 385 patients with meniscal tears was also done, to determine the extent of change in the axial alignment of the lower limb caused by the tear of the meniscus. Twelve patients in the LCD group, 23 in the LID group, 12 in the LS group, and 24 in the MS group (71 patients in all) were available for this comparison.

In this study, the so-called Mikulicz's mechanical axis[7] obtained at initial visit to our clinic was utilized to evaluate the axial alignment of the lower limb. This mechanical axis is a line drawn from the center of the femoral head to the center of the superior surface of the talus on an anteroposterior full-leg length radiograph, made with the patient standing on one leg and the knee joint in full extension. The point where the mechanical axis passes the level of the tibial articular surface was defined as the "M" point. The location of the "M" point was expressed as a percentage of the width of the tibial plateau. We defined the locations at the medial and lateral edges of the tibial plateau as 100% and −100%, respectively, and location in the middle of these as 0% (Fig. 1).

The values for "M" points in all groups were expressed as means ± SD (%), and for statistical analysis, the *t*-test was used in comparisons between two groups, and analysis of variance (ANOVA) with Scheffe's method was used when three groups or more were compared. $P < 0.05$ was regarded as significant.

The percentage of patients who had an obvious history of trauma at the time of symptom onset was calculated in the LCD, LID, LS, and MS groups.

Results

"M" point values in normal group

The "M" point values in the normal group were 26.1 ± 24.8% in males and 15.5 ± 21.6% in females, with a significant difference between these two groups ($P < 0.05$).

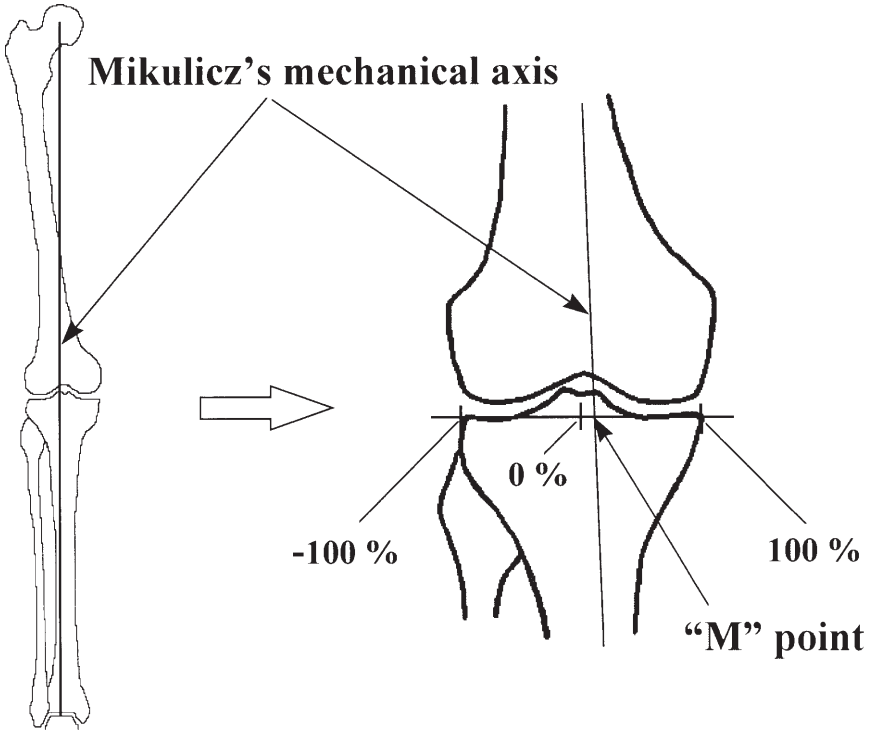

Fig. 1. The point where the so-called Mikulicz's[7] mechanical axis (a line drawn from the center of the femoral head to the center of the superior articular surface of the talus) passes the level of the tibial articular surface is defined as the "M" point

"M" point values for knees with meniscal tear and the asymptomatic, contralateral knees in each group

There were no significant differences between the involved and the contralateral knees in any comparisons of "M" points (Fig. 2).

"M" point values in male groups

The "M" point values in each male group are shown in Fig. 3.

The "M" points in the LCD group with a history of trauma were located more medially than those in the MS group with trauma (significant difference, $P < 0.05$). The "M" points of the LCD group with a history of trauma were located more medially than those of the normal group, but the difference was not significant.

We compared the subgroups without and with a history of trauma in each group (LCD, LID, LS, and MS). The "M" points in the MS group patients without a history of trauma were located more medially than those in the MS patients with a history of trauma (significant difference, $P < 0.05$); no other differences were significant.

"M" point values in female groups

The "M" point values in each female group are shown in Fig. 4.

The "M" points in the MS group without a history of trauma were located more medially than those in the normal group and those in the LCD, LID, and LS groups without a history of trauma (significant differences, $P < 0.05$).

We compared the subgroups without and with a history of trauma in each group, as for the males. Only in the MS group, were the "M" points of the patients without a history of trauma located more medially than those in patients in this group with a history of trauma (significant difference, $P < 0.05$).

Percentages of patients with obvious history of trauma in each group

These percentages were 21.1% in the LCD group, 30.0% in the LID group, 39.7% in the LS group, and 24.8% in the MS group.

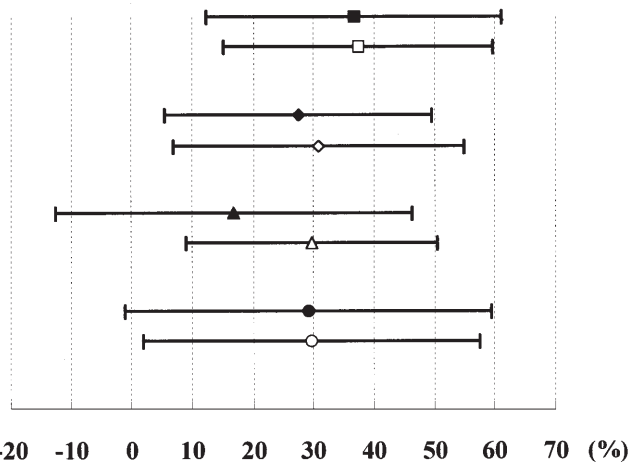

Fig. 2. Comparisons of involved and asymptomatic, contralateral knees in terms of "M" point values. *Symbols* indicate means of the "M" point and *bars* indicate SD. There were no significant differences in any comparisons (paired *t*-test) *Closed symbols* indicate the involved side and *open symbols*, the contralateral side. *Squares*, Lateral complete discoid (LCD) group; *diamonds*, lateral incomplete discoid (LID) group; *triangles*, lateral semilunar (LS) group; *circles*, medial semilunar (MS) group, contralateral side; *dots*, MS group, involved side

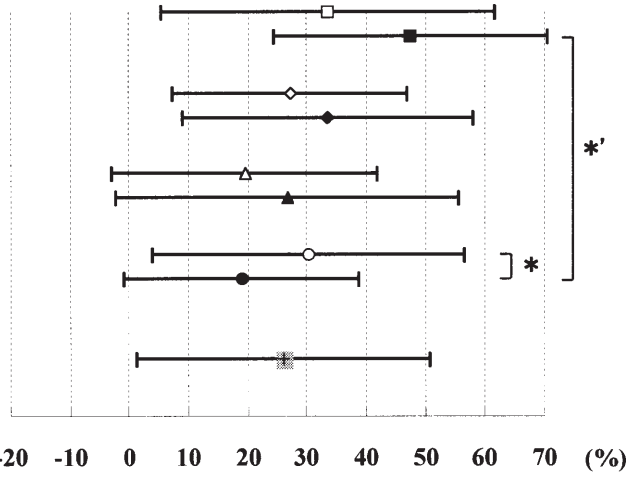

Fig. 3. "M" point values in male patients with isolated meniscal tear (groups LCD, *squares*; LID, *diamonds*; LS, *triangles*; and MS, *dots and circles*) and normal group (*crosses*). *Symbols* indicate means of the "M" point and *bars* indicate SD. *Open symbols*, patients without a history of trauma; *closed symbols*, patients with a history of trauma. * $P < 0.05$, unpaired *t*-test; *′ $P < 0.05$, analysis of variance (ANOVA) by Scheffe's method

Discussion

Meniscal tears are not always the result of trauma. Ferrer-Roca and Vilalta[2] stated that it was of interest that only 35% of their patients whose menisci had been removed had a history of trauma. In our study, the proportion of patients with a history of trauma was also low, namely, 39.7% with an isolated tear of the lateral semilunar meniscus and 24.8% with an isolated tear of the medial semilunar meniscus. Therefore, we believed

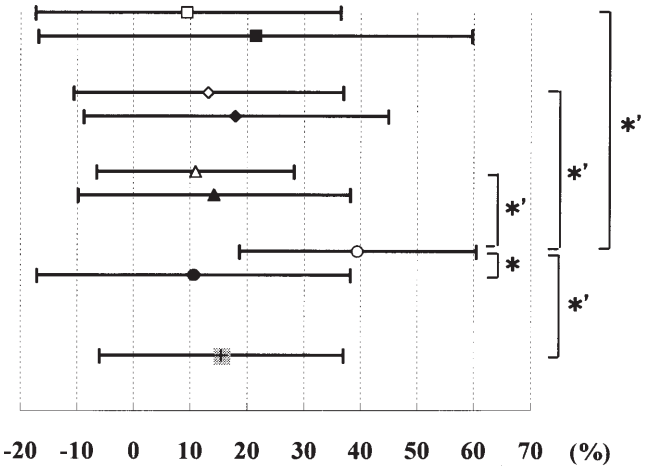

Fig. 4. "M" point values in female patients with isolated meniscal tear — groups LCD, LID, LS, and MS (*Symbols* as in *Fig. 3*) and normal group (*crosses*). *Symbols* indicate means of the "M" point and *bars* indicate SD. *Open symbols*, patients without a history of trauma; *closed symbols*, patients with a history of trauma. $*P < 0.05$, unpaired *t*-test; $*'P < 0.05$, ANOVA by Scheffe's method

that, in addition to the trauma, there were other important factors which caused meniscal tears, and consequently paid attention to the axial alignment of the lower limb in this study.

Although Bolano and Grana[1] and McBride et al.[6] suggested a relationship between varus deformity of the knee and medial meniscal tear by determining femorotibial angle with the patient in a standing position, this relationship was not discussed in detail. In contrast, we used Mikulicz's[7] mechanical axis to evaluate the axial alignment of the lower limb, because it can show a whole leg in addition to the curve of the femur and the tibia. As it is difficult to determine the anatomic axis of the tibia in patients with tibia vara, the femorotibial angle may be measured incorrectly. We also divided our patients into male and female groups and according to whether they had obvious trauma at the onset of symptoms.

If the values measured in Fujiwara's study[3] for the alignment of the lower limb in normal Japanese (30 males and 30 females, aged 21–40 years) were to be calculated by our method, the averages for the "M" points would be 22.2 ± 15.1% in males and 15.6 ± 14.6% in females. As these values were nearly equal to the values for our normal group, they may be regarded as appropriate values for the control group.

In our study, the axial alignment of the lower limb in normal Japanese differed between males and females, and it was significant that males had greater varus alignment of the lower limb than females ($P < 0.05$). This finding concurred with findings in Fujiwara's study.[3]

Although, to our knowledge how much the axial alignment of the lower limb is changed by tears of the meniscus has not been examined previously, we found that tears of the meniscus had little influence on the "M" point. Therefore, it appeared that the "M" point determined when a meniscal tear was present indicated the axial alignment of the lower limb before the meniscal tear occurred.

There were no significant differences in "M" point values in the LCD, LID, and LS groups between the subgroups without and with a history of trauma, and all three groups showed almost normal axial alignment in both males and females. Therefore, it was thought that the axial alignment of the lower limb was not related to the occurrence of meniscal tear in these three groups.

Female patients without a history of trauma in the MS group, had greater varus alignment of the lower limb than such females in the LCD, LID, and LS groups. In the MS group, also the lower limb in patients without a history of trauma was showed greater varus alignment than that in patients with a history of trauma, for both males and females. These results indicate that varus deformity may cause the medial meniscus to be susceptible to tear. While the precise mechanism is not clear, it seems varus deformity may induce degenerative changes in the medial meniscus.

Various groups have reported on the degeneration of the medial meniscus. Hasegawa et al.[4] examined 28 isolated torn medial menisci of the knees in teenagers; 11 of them had not experienced traumas. All 15 menisci examined histologically showed degenerative changes, the characteristics of which were hypocellurality, mucoid degeneration, and hyalinization. Degeneration was also seen in some menisci examined arthroscopically or histologically soon after injury. Noble[8] stated that typical early degenerative changes were found microscopically in 76% of grossly normal medial menisci examined and that these changes were seen in several subjects younger than 30 years of age. Jerosch et al.[5], using magnetic resonance imaging, identified degeneration of menisci in asymptomatic athletes.

We found degenerative changes in 56 of 59 resected menisci from patients without a history of trauma in the MS group. These changes were seen in 7 examined within 1 month after the onset of symptoms. These findings indicate that obvious meniscal tear developed following degeneration of the meniscus.

Medial or lateral meniscal tears occurring in bilateral knees were excluded from this study. Between 1972 and 1994, bilateral isolated tears of lateral semilinar meniscus were found in 2 of 70 patients, the rate of occurrence being 2.9%. On the other hand, medial semilunar meniscus tears were found in 19 patients with bilateral injury (14 without a history of trauma and 5 with a

history of trauma) in the same period, the rate being 14.0% (19/136).

When we divided the MS group without a history of trauma into a varus and a valgus group by the "M" point values in our normal group, 45 male patients (62.5%) and 14 female patients (87.5%) belonged to the varus group. These findings suggest that varus deformity of the knee may be related to medial meniscal tear.

We speculate that, even without obvious trauma, the daily load stress to the knee produces degeneration of the medial meniscus in the varus knee, leading to a later meniscal tear. The medial meniscus is closely attached to the deep layer of the medial collateral ligament at its middle segment, resulting in relatively low mobility. In comparison with the lateral meniscus, the medial is broad and thick, particularly in the posterior segment. These conditions may explain why the medial meniscus is more prone to be influenced by load stress than the lateral meniscus.

Conclusions

1. The axial alignment of the lower limb does not appear to have a relationship with the occurrence of isolated tears of lateral complete discoid meniscus, lateral incomplete discoid meniscus, or lateral semilunar meniscus, as the axial alignments of the lower limb were normal in patients in all these groups.

2. The axial alignment of the lower limb is varus in patients with isolated tears of medial semilunar meniscus without obvious trauma, although the alignment is almost normal in those with obvious trauma. Therefore, it seems that varus deformity of the knee is closely related to the occurrence of this tear.

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