Insufficient restoration of meniscal tension during surgical repair of medial meniscus root tear is associated with poor surgical outcomes: Clinical implication of curtain-cliff sign

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INTRODUCTION: Despite the clinical benefits over non-operative treatment or meniscectomy, the clinical outcomes of surgical repair for medial meniscus posterior root tear (MMRT) remain suboptimal, which may be attributed to the insufficient restoration of meniscal hoop tension during surgery. Therefore, this study aimed to analyze the clinical outcomes of surgical repair for MMRT based on the appearance of the meniscal tension observed immediately after surgery.

METHODS: Electronic medical records of patients who underwent arthroscopic transtibial pull-out repair of MMRT between 2010 and 2021 were retrospectively reviewed. Patients with at least a 2-year follow-up and whose overall meniscal status after the surgical repair could be evaluated via arthroscopic images or videos were eligible to be included. Patients were classified based on the presence of the curtain-cliff sign, potentially implying the postoperative meniscal hoop tension (group 1, patients without curtain-cliff sign; group 2, patients with curtain-cliff sign) (Figure). Regression analysis was performed to evaluate whether the curtain-cliff sign reflects postoperative meniscus extrusion. Subsequently, comparative analyses were conducted between two groups regarding baseline demographic data, clinical scores, intra-operative data, and radiographic parameters.

RESULTS:

A total of 79 patients were included. Regression analysis revealed a significant association between the curtain-cliff sign and postoperative meniscus extrusion, suggesting its potential to reflect the postoperative meniscal tension (Table 1). In the between-group comparisons, there were no differences in baseline demographic data, preoperative clinical scores, and preoperative radiographic variables. However, at the final follow-up, group 2 showed a significantly lower International Knee Documentation Committee subjective score compared to group 1 (P = 0.017). Additionally, group 2 exhibited significantly higher postoperative meniscus extrusion and more pronounced progression compared to preoperative status. Consistently, the progression of both the osteoarthritis grade and the hip-knee-ankle angle compared to preoperatively was significantly greater in group 2 (Table 2).

DISCUSSION AND CONCLUSION:

The curtain-cliff sign cannot exclude the possibility of being influenced by various factors besides meniscal tension. For instance, the non-anatomic placement of the intra-articular trans-osseous tibial tunnel may potentially induce this sign, but this study found no between-group differences in the anatomical placement of the trans-osseous tunnel. However, other factors, such as pull-out tension during knot tying and valgus force applied to the knee joint during observation of the repair site during surgery, could have affected the manifestation of this sign. Nevertheless, as the surgical procedures were consistently performed by a senior surgeon and thoroughly evaluated based on the recorded arthroscopic images or videos, regardless of the purpose of this study, this sign is deemed to have sufficient clinical significance. Surgeons should endeavor to secure adequate tension during surgical repair for MMRT to prevent the occurrence of the curtain-cliff sign. Additionally, if this sign is observed, consideration should be given to additional surgical procedures, such as centralization procedures, to reinforce meniscal tension.

In conclusion, in patients where the restoration of meniscal tension appears insufficient immediately after surgical repair for MMRT, relatively poor clinical outcomes can be anticipated. The findings of this study suggest that efforts to reinforce meniscal tension may be required during surgical repair for MMRT in some cases, especially those showing the curtain-cliff sign.

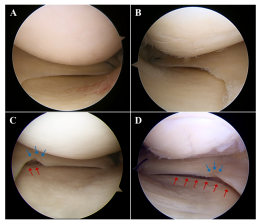

Table 1. Simple Linear Regression Analysis for the Association between the Curtain-Cliff Sign and Meniscus Extrusion Measured at Postoperative 1 Year

Variable	Beta coefficient	95% confidence interval	*P* value
Model 1[a]			
Curtain-Cliff Sign			
No (Reference)	3.986	3.615 to 4.357	< .001
Yes	1.137	0.374 to 1.9	.004
Model 2[b]			
Curtain-Cliff Sign			
No (Reference)	4.357	3.971 to 4.743	
Yes	1.327	.534 to 2.121	.001

[a] Analysis with the meniscus extrusion measured at mid-point of the medial femoral condyle

[b] Analysis with the meniscus extrusion measured at posterior border of the medial collateral ligament

Table 2. Comparison of Radiographic Parameters

Variables[a]	Group 1 (n = 59)	Group 2 (n = 20)	*P* value
Preoperative			
Kellgren-Lawrence grade, AP view, 0/1/2[b]	16/42/1	8/11/1	.252
Kellgren-Lawrence grade, Schuss view, 0/1/2[b]	7/44/8	5/14/1	.274
HKA angle, °	3.9 ± 2.9	3.8 ± 1.8	.852
Posterior tibial slope, °	7.8 ± 2.2	7.8 ± 2.2	.991
Meniscus extrusion (mid-point of the MFC), mm	3.0 ± 0.8	3.0 ± 1.0	.949
Meniscus extrusion (posterior border of the MCL), mm	3.5 ± 1.0	3.3 ± 1.1	.507
Postoperative 1-year			
Meniscus extrusion (mid-point of the MFC), mm	4.0 ± 1.1	5.1 ± 1.5	.004
Meniscus extrusion (posterior border of the MCL), mm	4.4 ± 1.2	5.7 ± 1.5	.004
Δ meniscus extrusion (mid-point of the MFC), mm[c]	0.9 ± 1.1	2.1 ± 1.3	.002
Δ meniscus extrusion, (posterior border of the MCL), mm[c]	0.9 ± 1.1	2.4 ± 1.7	.003
Healing of MMRT, complete/partial/no[b,d]	29/12/1	8/4/1	.593
Final follow-up			
Kellgren-Lawrence grade, AP view, 0/1/2/3[b]	4/40/15/0	1/10/8/1	.176
Kellgren-Lawrence grade, Schuss view, 0/1/2/3[b]	3/26/28/2	1/6/10/3	.236
Δ Kellgren-Lawrence grade, AP view, 0/1/2[b,c]	33/26/0	5/14/1	.016
Δ Kellgren-Lawrence grade, Schuss view, 0/1/2[b,c]	33/24/2	4/13/3	.007
HKA angle, °	4.9 ± 3.2	5.6 ± 1.9	.347
Δ HKA angle, °[c,d]	1.0 ± 1.0	1.8 ± 1.4	.005

HKA, Hip-Knee-Ankle; MFC, medial femoral condyle; MCL, medial collateral ligament; Δ, The difference of value between two time points; MMRT, Medial meniscus root tear.

[a] The values are given as the mean and standard deviation, otherwise noted separately

[b] The values are given as number of patients

[c] Compared to before surgery

[d] Analysis of patients who underwent follow-up MRI